The peculiarities of water use in the Răut river basin (Republic of Moldova)

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Abstract: The purpose of this research consists in the elucidation of spatial and branch aspects of the water use in the Răut river basin. The main topics presented in this paper are: the dynamics of water use in this basin; regional aspects of water use; dynamics of water use by the main usage categories; branch profile of water use and its dynamics; existing problems in the evaluation and monitoring of water use. To achieve these objectives were used traditional methods of geographical and economic research. Also, the content of the present study is focused on the methodology to elaborate the management plans of hydrographical basins and their chapters on economic analysis of water use in a river basin.

Key words: water use, Răut, river basin, climate changes, agriculture, household.

1. INTRODUCTION

The introduction should briefly place the study in a broad context and highlight why it is important. It should define the purpose of the work and its significance. The Răut River is the right tributary of the Dniester River and is the longest river (286 km) that wholly runs in the Republic of Moldova (Figure 1). The surface of the water catchment of the river Răut is 7,760 km² or 23% of the territory of the Republic of Moldova [1]. The watersheds are well expressed and the altitude varies from 230 m to 388 m. The rock foundation of the basin consists of sands, chalks, marl of Cretaceous age, covered with a layer of limestone and clay rocks of Tortonian origin.

The Răut river basin is situated within the limits of the Cubolta Plain, the Dniester Plateau and the Central Moldavian Plateau. The average of the annual rainfall is 450-500 mm and the average of the annual temperature is 8-9°C. The hydrographic network is well-developed (0.48 km/km²), soils being predominated by chernozemsoils, alluvial soils and forest gray soils.

The main part of the basin inclines towards the southeast, which determines the direction of the river drain. In the Codrii Plateau, the relief is fragmented by a wide and deep valleys network with asymmetrical slopes, fragmented in turn by ravens and bumps. The lower course has a high degree of relief fragmentation, the erosion, suffusion and karst processes being frequently spread [2] (pp. 11-23).

Arable lands occupy more than half of the total land area and about ³/₄ of the agricultural land of the hydrographic basin of Răut river basin. There are cultivated cereals and technical plants, fruit trees, and in irrigated areas, vegetable farming is largely practiced. The arable lands are concentrated mainly in the northern and southern parts of this river basin, which is characterized by a lower relief fragmentation.

The Răut river basin includes areas of the municipality of Bălți and of 18 administrative districts (Figure 2). Within the Răut river basin totally includes the Bălți municipality and the districts of Dondușeni, Drochia, Sângerei and Telenești. Also, large proportionis of Orhei (90%) and Florești (73%) districts are included here. An average share is specific for districts of Soroca (45%), Râșcani (40%) and Rezina (38%), and a reduced share – for the other 9 districts, including Călărași (25%), Şoldănești (23%), Fălești, Criuleni (21%), Ungheni (18%), Glodeni (14%), Ocnița (11%) and Dubăsari (10%).

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Figure 1. The hydrographical network of Republic of Moldova. Source: Management Plan of Dniester Hidrographical District [3]

Within the river basin Răut are located 248 localities, including 11 towns and 237 villages. Most settlements are registered in the districts, which are wholly or predominantly included within the the respective river basin, including Orhei and Telenești (31), Florești (28), Drochia and Sângerei (27), Dondușeni (25). The minimum number can be seen in Bălți municipality (3), as well as in insignificant of its area districts in the Răut river bazin, including Edineț and Dubăsari (1), Glodeni and Ocnița (2). The total number of population is about 780,000 inhabitants, of which about 70% is the rural population [4]. The reduced share of urban population is also conditioned by the fact that in the most of the districts (11 of 18), urban centers are located outside of Răut river basin. The maximum number of inhabitants is recorded in the Bălți municipality (152,000), as well as in the districts of Orhei (102,000), Sângerei (92,000), Drochia (86,000), Telenești (72,000) and Florești (65,000). The minimum number is registered in distrcts of Edinet (1.2 thousand) and Dubăsari (3.5 thousand), out of which only 1 village situated in the Răut river basin for each, as well as in the districts of Glodeni (7.7 thousand) and Ocnița (5.0 thousand), with 2 communes situated in the Răut river basin, Şoldănești (9.1 thousand) and Ungheni (9.4 thousand).

2. LITERATURE REVIEW

Recently, water resources have become one of the most important issues of the global sustainable development. Climate change, environmental pollution, and continued industrialization directly and continuously affect these vital resources [5,6]. The recent intensification of natural and anthropogenic risks alarmingly affects the water supply capability of the population and of the economic activities in most of the world's countries. Complex assessment of water resources and their consumption in relation

to the manifestation of these risks becomes a priority research direction for geographic, social and economic sciences [7]. In addition, geographic research has the advantage of achieving the complementarity of ecological, social and economic studies, having as the main objective: sustainable use and efficient management of water resources. Geographic surveys also play a leading role in creating methodological and scientific support for the application of OECD principles on good water governance [8], including the principles of regionalization and decentralization of water management, actively promoted by the OECD, both in the developed states and in the developing countries [7,9].



Figure 2. The administrative-territorial composition and sources of water supply in the districts of Răut river basin. Source: State Ecological Inspectorate [10] and National Agency "Apele Moldovei" [11]

In the European countries, the research and protection of the Danube river basin is of major importance, due to the fact that 16 countries take part of this river basin, on the basis of which many researches related to various climate scenarios were made [12], as well as the impact of climate changes on water [13-15], the sustainability of water supply and water sanitation [6,7,16]. At national level, the adaptation and harmonization of the Water Framework Directive is reflected in the Water Law of the Republic of Moldova, which came into force on October 26th, 2013. Thus, among the objectives of both the Water Framework Directive and the Water Law of the Republic of Moldova, a pivotal role lies with the elaboration of the River Basin Management Plans (RBMP). Within the RBMP, a great attention is paid to the economic analysis of the of water use. These aspects are also approached in this work. Numerous studies in the Republic of Moldova [3,17,18] are directed to the Dniester hydrographic basin which is the main water resource, being a cross-border river and, based on them, various scenarios, reports and plans being elaborated. The works listed above superficially refers to the theme of economic water analysis, especially for the catchment area of the river for which no such research has yet been done. The river basin of the Răut covers territories of about 18 districts, and its water resources, although of major importance in the water supply, are not sufficiently studied. That is why this study, based on national and international researches on this topic, was proposed to be carried out.

The present research is based on recent analytical studies on the implementation of the Management Plan of River Basin, which is stipulated in EU Directive (2000/60/EC) on integrated water management [19]. For the study, the authors have focused on management plans, which are being implemented, such as the Danube River Basin Management Plan [20], Management Plan of Prut-Bârlad River Space [21],

Management Plans of Prut river basin [22] and of Danube Prut and Black Sea Hydrographical District [23]. Those plans must include detailed diagnosis of the status of basins and of water bodies, recent trends of water consumption, and economical analysis of water use. Based on this diagnosis are established shortcomings and achievements of current water management and action plans shall be drafted to improve the status of water and increase the economic and environmental efficiency of its use. Very valuable, in particular for analysis of water use are research methodology and study of transboundary rivers in the Black Sea Region and Belarus (EPIRB Program) [24]. Also, for the elucidation of spatial, economic and social aspects of water use in Moldova, various publications in the field have been consulted [1,25], as well as analytical studies of authors of this article [22,23,26,27].

3. METHODS AND DATA

The main methods, which are used in this study, are: statistical, analytical, comparative, analogical, as well as consultation with competent authorities in the field of assessing and managing of water resources. Statistical method was widely used in processing of statistical information on the water use in the in all administrative-territorial units from the Răut river basin. The analytical method was used for: a) to identify quantitative and qualitative aspects of water use; b) diagnosis of situation of water use and elaboration of recommendations to prevent problematic situations in this field; c) definition of priority directions of activity optimization of water resources management in the river basins. The comparative method was applied for establishing the trends in the branch and spatial aspects of the water use.

The main informational and statistical support of this study included: 1) Generalized Annual Reports on Water Management Indicators of the Basins Department of Agency "Apele Moldovei" [11]; 2) Annual Reports of Ecological Agencies and Inspection [10]; The Reports on water supply and sanitation companies of Association "Moldova Apa-Canal" [28]; The Report of of National Bureau of Statistics on the public water supply and sewerages networks [29]. The study comprised the 2007-2017 years.

4. RESULT AND DISCUTIONS

In the period between 2007 and 2017, in the Răut river basin were used, on average, 18 million m³ of water or only 2.3 % of the total volume of used water in the Republic of Moldova and 15,6 % from used water on the right bank of the Dniester river. The reduced share is due to the predominance of small and medium-sized towns and to the pronounced rural character of the region study. The volume of water used is conditioned by the surface of the respective districts within the Răut hydrographical basin, by the number and dimensions of urban centers and rural settlements with extensive public aqueducts from the perimeter of this river basin, by the monitored irrigated areas, and by accounted water consumption for agricultural and household purposes [27].

| No | Districts | Total | Surface water | | Groundwater | | Households | | Industry | | Agriculture, incl. irrigation | | | |
|----|------------|--------------------|--------------------|----|--------------------|-----|--------------------|-----|--------------------|------|-------------------------------|----|--------------------|----|
| | 210011000 | ths m ³ | ths m ³ | % | ths m ³ | % | ths m ³ | % | ths m ³ | % | ths m ³ | % | ths m ³ | % |
| 1 | Ocnița | 126 | 39 | 31 | 88 | 69 | 16 | 13 | | | 110 | 87 | 33 | 26 |
| 2 | Donduşeni | 1,045 | 371 | 36 | 673 | 64 | 227 | 22 | 90 | 8.6 | 729 | 70 | 195 | 19 |
| 3 | Soroca | 615 | 287 | 47 | 329 | 53 | 159 | 26 | 27 | 4.4 | 429 | 70 | 122 | 20 |
| 4 | Drochia | 1,835 | 403 | 22 | 1,433 | 78 | 484 | 26 | 199 | 10.9 | 1,151 | 63 | 317 | 17 |
| 5 | Florești | 1,739 | 215 | 11 | 1,602 | 90 | 452 | 26 | 327 | 18.8 | 960 | 55 | 192 | 11 |
| 6 | Sângerei | 1,573 | 287 | 18 | 1,285 | 82 | 480 | 31 | 61 | 3.9 | 1,032 | 66 | 285 | 18 |
| 7 | Râșcani | 1,024 | 307 | 30 | 717 | 70 | 300 | 29 | 36 | 3.5 | 688 | 67 | 154 | 15 |
| 8 | Glodeni | 39.9 | | | 39.9 | 100 | 39.9 | 100 | | | | | | |
| 9 | Fălești | 331 | 86 | 28 | 239 | 72 | 196 | 59 | 13 | 3.8 | 122 | 37 | 60.5 | 18 |
| 10 | Bălți | 4,951 | 4,436 | 90 | 485 | 10 | 3,404 | 69 | 1,381 | 27.9 | 167 | 3 | | |
| 11 | Şoldăneşti | 132 | 13,6 | 3 | 118 | 97 | 13.3 | 10 | | | 118 | 90 | 19.3 | 18 |
| 12 | Rezina | 174 | 36 | 21 | 138 | 79 | 72 | 41 | 10 | 5,8 | 92 | 53 | 13 | 7 |
| 13 | Telenești | 1,224 | 259 | 21 | 968 | 79 | 444 | 36 | 40 | 3.3 | 740 | 60 | 259 | 21 |
| 14 | Ungheni | 137 | 67.2 | 49 | 69.7 | 51 | 59.5 | 43 | 15.7 | 11 | 61.7 | 45 | 18.9 | 14 |
| 15 | Călărași | 170 | 12 | 7 | 158 | 93 | 78 | 46 | 10.4 | 6.1 | 82 | 48 | 13 | 8 |
| 16 | Orhei | 2,668 | 467 | 17 | 2,201 | 83 | 1,104 | 41 | 323 | 12.1 | 1,241 | 47 | 385 | 14 |
| 17 | Criuleni | 199 | 64 | 32 | 136 | 68 | 75 | 37 | | | 125 | 63 | 84 | 42 |
| 18 | Dubăsari | 63 | 53 | 84 | 11 | 16 | 8.6 | 14 | | | 55 | 86 | 55 | 86 |
| | Total | 18,039 | 7,365 | 41 | 1,0672 | 59 | 7,603 | 42 | 2,533 | 14 | 7,903 | 44 | 2,185 | 12 |

Table 1. The volume and share of used water, by abstracted sources and usage categories, in the Răut river basin (average of 2007-2017 years).

Source: State Ecological Inspectorate [10] and National Agency "Apele Moldovei" [11]

Therefore, the maximum water consumption is attested in the Bălți municipality (5.0 mil. m³) and in the districts of Orhei (2.7 mil. m³), Drochia (1.8 mil. m³), Florești (1.7 mil. m³) and Sângerei (1.6 mil. m³) and the minimum water use – in the smaller districts, such as Glodeni, Ocnița, Șoldănești and Dubăsari (Table 1).

On average, $\approx 60\%$ of used water is abstracted from underground sources, which predominates in the absolute majority of districts and localities from the Răut river basin (Figures 3, 4), with the exception of Bălți municipality and Dubăsari district, which is supplied with water from the Dniester riverbed.

Compared with 1990 year, there is a reduction of about 13 times in the volume of abstracted water. This situation is due, on the one hand, to the multiple reduction of the volume of water used in agriculture and industry, as a result of deep and prolonged decline of these economic sectors and, on the other hand, to the superficial evidence of the use of water resources, especially in agriculture and mining industry [10-11]. During the analysed period (2007-2017), the total volume of water used registered an oscillating evolution on the background of a generally negative slow trend, by about 5% (Table 2). The negative growth is registered in the Bălți municipality and in half (10 of 18) of districts from Răut river basin included in the present study. The positive dynamics is observed in the districts of Donduşeni (2.3 times), Soroca (+ 21%), Floresti (+17%), Teleneşti (+14%), Călăraşi (+13%), Făleşti (+8%) and Dubăsari (+7%), being caused predominantly by the increase of water systems [11], especially in the rural area and the increased consumption of water after 2013, there is a positive trend in the absolute majority of the districts from the study region.



Figure 3. Sources of abstracted water in the Răut river bazin. Source: State Ecological Inspectorate [10] and National Agency "Apele Moldovei" [11]



Figure 4. The usage categories of water in the Răut river bazin. Source: State Ecological Inspectorate [10] and National Agency "Apele Moldovei" [11]

The total volume of used water from surface sources has decreased by $\approx 20\%$. The negative dynamics are recorded in the Bălți municipality and in the 9 of the 15 districts from the Răut river basin, which are included in this study. The maximum reduction of the used surface water is observed in the districts of Orhei, Şoldăneşti and Rezina (by 5 times), Drochia and Călăraşi (by 4 times), Sângerei (by 3.5 times), Criuleni (by 2.4 times). The significant decrease in the volume of water used from surface sources is not only due to the influence of natural factors, to the worsening of the situation in the national agriculture, to the increased degree of wear of hydrotechnical installations or massive lack of there, but also to the superficial record of the water used for agricultural or mining purposes [12]. The increase in the volume of water used from surface sources is recorded only in the districts of Donduşeni (by 6.2 times), Teleneşti (+ 44%), Soroca (+ 28%) and Făleşti, wich is due to the similarly increasing of the water used in the large agricultural companies from these districts, as well as the extension of the Prut - Făleşti aqueduct [23].

Unlike the surface waters, the volume of water used from underground sources in the Răut river basin shows a positive dynamic with about 9%, which is found in the majority (9) districts of the region. This situation is due to the recent extension of the centralized water supply network, especially for the household needs [29] of the rural population and the majority of water is abstracted through artesian wells built and modernized with the financial support of the National Ecological Fund, German Technical Assistance Fund (GIZ), Austrian Development Agency (ADA), Swiss Agency for Development and Cooperation (SDC) and other financing sources. The absolute majority of these projects are intended for

the water supply of the population and are based predominantly on the exploitation of the underground water in the perimeter of the rural localities [23]. At the same time, a great part of newly built water supply networks are not completed with centralized sewerage networks and wastewater treatment plants, which significantly increases harmful impact on the natural environment and the human body. A negative increase in the volume of water used from underground sources is found in Bălți municipality (2.6 times) as a result of its connection to the Soroca-Bălți main water pipeline, as well as in the districts of Râșcani, Sângerei (-16%), Şoldănești, Fălești and Dondușeni.

For agricultural purposes were used, on average, 7.9 million m³ or 44% of the total volume of water used in the Răut river basin (Table 1). About 7.6 million m³ or 42% were used by households and 2.5 million m³ or 14% of the total volume of water was used for technological needs (Figure 4). The high shares of water used for agricultural and domestic purposes are due, on the one hand, to Bălți municipality, which is consuming 45% of the total volume of water used for domestic purposes in the Răut river basin [10,11], and on the other hand, to the massive the agricultural use in most districts and localities of the study region. In addition, water used for domestic needs is not only provided by municipal operators but also by industrial and agricultural companies, in particular by the sugar and wine factories.

The maximum (\geq 70%) share of agriculture is recorded in the districts of Soldănești, Ocnița, Dubăsari, Donduseni and Soroca (Table 1), where operate the big agricultural enterprises, which massively use water for irrigation and other agricultural activities [10]. Also, over 60% of the abstracted waters in the most districts of the region is used in agriculture, including in the districts where the urban centers are located outside of the Răut river basin.

| No | Districts | Years | | | | | | | | | Avorago | Growth | | |
|-----|-----------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|--------|---------|-----|
| NO. | Districts | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Average | % |
| 1 | Ocnița | 152 | 142 | 155 | 128 | 139 | 104 | 108 | 107 | 119 | 119 | 118 | 126 | 78 |
| 2 | Dondușeni | 820 | 770 | 980 | 880 | 1,000 | 970 | 920 | 880 | 1,040 | 1,390 | 1,843 | 1,045 | 225 |
| 3 | Soroca | 548 | 500 | 613 | 575 | 593 | 603 | 655 | 643 | 735 | 645 | 663 | 615 | 121 |
| 4 | Drochia | 2,170 | 1,710 | 1,610 | 1,480 | 1,530 | 1,750 | 2,110 | 1,900 | 1,920 | 1,960 | 2,040 | 1,835 | 94 |
| 5 | Florești | 1,666 | 1,513 | 1,632 | 1,590 | 1,658 | 1,624 | 1,751 | 1,913 | 1,896 | 1,930 | 1,955 | 1,739 | 117 |
| 6 | Sângerei | 1970 | 1,700 | 1,840 | 1,760 | 1,760 | 1,660 | 1,250 | 1,310 | 1370 | 1,340 | 1,340 | 1,573 | 68 |
| 7 | Râșcani | 1,430 | 1,100 | 1,177 | 1,106 | 1,040 | 1,007 | 968 | 825 | 809 | 853 | 952 | 1,024 | 67 |
| 8 | Glodeni | | | 40.4 | 39.0 | 40.0 | 39.4 | 39.2 | 40.4 | 40.4 | 40.4 | 39.8 | 39.9 | 99 |
| 9 | Fălești | 280 | 300 | 288 | 314 | 276 | 566 | 384 | 360 | 294 | 279 | 304 | 331 | 108 |
| 10 | Bălți municipality | 5,370 | 5,350 | 5,536 | 5,120 | 5,050 | 4,710 | 4,680 | 4,720 | 4,770 | 4,600 | 4,560 | 4,951 | 85 |
| 11 | Şoldănești | 131 | 135 | 167 | 162 | 156 | 122 | 119 | 119 | 119 | 114 | 108 | 132 | 83 |
| 12 | Rezina | 192 | 186 | 210 | 194 | 189 | 162 | 156 | 155 | 159 | 156 | 158 | 174 | 82 |
| 13 | Telenești | 1,200 | 1,080 | 1,240 | 1,150 | 1,190 | 1,070 | 1,080 | 1,320 | 1,380 | 1,380 | 1,370 | 1,224 | 114 |
| 14 | Ungheni | 160 | 120 | 135 | 121 | 134 | 146 | 135 | 133 | 145 | 139 | 140 | 137 | 88 |
| 15 | Călărași | 159 | 156 | 191 | 167 | 156 | 165 | 174 | 174 | 177 | 177 | 180 | 170 | 113 |
| 16 | Orhei | 3,168 | 2,560 | 3,008 | 2,760 | 2,784 | 2,632 | 2,448 | 2,432 | 2,384 | 2,528 | 2,648 | 2,668 | 84 |
| 17 | Criuleni | 216 | 163 | 176 | 181 | 208 | 217 | 187 | 233 | 228 | 193 | 191 | 199 | 88 |
| 18 | Dubăsari | 95 | 68.9 | 59.5 | 51 | 35 | 33 | 32.5 | 35 | 87 | 92 | 102 | 63 | 107 |
| | Total | 19,284 | 17,157 | 18,600 | 17,365 | 17,508 | 17,207 | 16,835 | 16,939 | 17,288 | 17,562 | 18,344 | 17,644 | 95 |

Table 2. The dynamics of total volume of water use in the Răut river basin (in thousand m³).

Source: State Ecological Inspectorate [11] and National Agency "Apele Moldovei" [12]

Therefore, in this basin, the amount of water used in agriculture directly conditions the total volume of used water and its spatial distribution. The minimum share is observed in the Bălți municipality (3%), as well as in the Glodeni, Ungheni, Orhei and Călărași districts, because data on water use in rural areas in those districts were provided, almost exclusively, by the public water supply companies, which mainly serve households and budget organizations [10,11,28]. At the same time, in the rural localities, the water received by the population is massively used for animal husbandry and for irrigation of domestic crops.

The volume of water used in agriculture, especially for irrigation, is conditional on the available surface water resources, by the density of the hydrographical network, by the length and flow of watercourses, by the number, surface and condition status of accumulation reservoirs within the perimeter of that hydrographical area, the level of evidence of water used in agriculture, as well as the technical and economical possibilities of using water by farmers [27]. Thus, the maximum water consumption is recorded in the *large agricultural companies with complex profile*, especially from districts of Drochia (1 million m³), Donduşeni (700,000 m³), Sângerei, Orhei, Teleneşti and Dubăsari; *the poultry*

factories from Dondușeni districts (16,000 m³), Râșcani (28,000 m³), Orhei (26,000 m³); *the pigs complexes* (17,000 m³), Florești (20,000 m³) and Râșcani [10].

For irrigation, are used, on average, 2.2 million m³ (12%) from total volume of water in the Răut river basin. The maximum volume of water used for irrigation is observed at the big agricultural companies from mentioned districts, which use their own irrigation systems or of zonal irrigation stations, especially in the districts located near the Dniester River, with a higher water flow [3]. The relatively low volume of water used in irrigation is conditioned both by the natural conditions (low flow and insufficient rainfall, increased risk of soil salinization) and the technical and economic possibilities of water used for irrigation in respective region.

The volume of water used in agriculture decreased, on average, with over 1/4 or from 9.9 million m³ to 7.2 million m³ (Figure 5). The negative growth of the volume of water used for these purposes is recorded in most districts of the Răut river basin, and the maximum reduction is recorded in the districts of Orhei (\approx 4 times), Sângerei and Criuleni (3 times), Râșcani and Fălești (2.5 times). At the same time, the positive dynamics of the volume of water used in agriculture is observed in the districts of Florești (3.6 times), Donduseni (2.3 times) and Telenești (+11%). This is due to big agricultural companies from these districts, especially of farms specialised in the growing of fruit and cereals for export, including SRL "Climăuțeanu Agro" from Dondușeni district (602,000 m³), SRL LobiLojistic (78,000 m³) from Telenești district [10].

The volume of *water used for irrigation* in Răut river basin was reduced by 2.3 times, including in the districts of Drochia and Rezina (9 times), Orhei and Călăraşi (6 times), Şoldăneşti (5 times), Râşcani, Sângerei and Criuleni (3 times). At the same time, the positive dynamics of the volume of water used in irrigation is observed only in the districts of Donduşeni (\approx 2 times) and Teleneşti (+ 44%), which is due to the above mentioned big agricultural enterprises. As a result of the continuous manifestation of the negative tendency of the volume of water used for these purposes, agriculture uses give up the first position to household sector. Thus, in 2017, for agricultural purposes only 7.2 million m³ were used, or only 39 % of the total volume of water used in the Răut river basin (Figure 5).



Source: State Ecological Inspectorate [10] and National Agency "Apele Moldovei" [11]

For *domestic purposes* 7.6 million m³ were used, on average, or 42 % of the total volume of used water. The maximum volume of water used for these purposes it is noted in the Bălți municipality (3.5 million m³), in the districts of Orhei (1.1 million m³), Drochia (484,000 m³), Sângerei (480,000 m3), Florești (452,000 m³) and Telenești (444,000 m³). This is conditioned by the number and dimensions of the served urban centers and rural localities, which have extensive public water supply systems and record the abstracted and delivered waters [29]. The maximum share of domestic water needs is observed in the districts of Glodeni (100%), Fălești (59%) and in Bălți (69%), but the minimum share (25%) is attested in the northern districts and in the Dubăsari district. Among the district centers, maximum water consumption for domestic purposes is registered, also, in the Orhei (1.1 million m³), Florești (421,000 m³), Sângerei (406,000 m³), and Drochia towns (342,000 m³) [28]. Also, a maximum consumption of domestic

water is recorded in the rural localities of districts Orhei (600 thousand m³), Teleneşti (350 thousand m³), Sângerei (324 thousand m³), Donduşeni (315 thousand m³) and Floreşti (300 thousand m³). A significant volume of water is used by the medical centers in the district centers, especially in the towns of Bălți, Drochia (177 thousand m³), Orhei (40.1 thousand m³), the city halls and the educational centers in the big rural localities [10].

As a result of the rapid expansion of public water supply systems [28] and of accounted water consumption, especially in the rural areas, the volume of water used for domestic purposes increased, on average, by more than 50% (Figure 5). The highest increase is recorded in the districts of Criuleni (4.3 times), Dubăsari (3 times), Sîngerei and Râscani (2.4 times), Dondușeni, Drochia and Telenești (2.3 times), Orhei (2. 2 times). The negative dynamics are only observed in the districts of Ocnița (-20%) and Rezina (-15%). The significant increase in the volume of water used for these purposes led to a similar increase in the share of household use, and the gradual establishment on the first position in the branch structure of water consumptionin within the Răut river basin. Therefore, in 2017, the share of household use exceeded $\frac{1}{2}$ of the total volume of water used in this river basin (Table 1).

In the *industry* are used, on average, 2.5 million m³ of water, or 14% of the total volume of water used in the Răut river basin, including 1.4 million m³ (56%) used by the enterprises from Bălți municipality [11]. Also, a high water consumption in industry is recorded in the districts of Florești (327,000 m³), Orhei (323,000 m³) and Drochia (330,000 m³) and it is due to the larger urban centers in these districts and the presence of the rich base of raw materials, especially for the food industry and the building materials industry, which use big volume of water [10].

The biggest water consumers in the food industry are: *sugar factories* from Drochia (120,000 m³) and Donduşeni (138,000 m³); *wine factories and other alcoholic beverages* from Bălți (40,000 m³), districts Orhei (15,500 m³), Călăraşi; *dairy factories* "Incomlac" SA from Bălți (133,000 m³), from Râscani (20,000 m³), Florești and Orhei towns; *juice and canning factories* "OrheiVit" SA (267,000 m³) and "Natur Bravo" SA from Florești (19,500 m³); *grain processing plants* from Bălți (30,000 m³), districts of Florești (87,000 m³), Dondușeni and Fălești (Răuțel); *oil production factories* "Floarea Soarelui" SA from Bălți (131,000 m³) and Florești; *bakery factories* from Bălți and districts centers; *companies for bottling of mineral water* from Bălți, and from districts of Florești (164,000 m³) and Sângerei (19,300 m³); *enterprises of sausages-producing* "Basarabia Nord" SA from Bălți (73,800 m³) and Râșcani; *bakeries, mills and cottages* in the countryside; *public catering enterprises* (restaurants, cafes, pubs).

The largest water consumers in the mining and building materials industry are: *quarries for the extraction of limestone* in the districts of Râşcani, Orhei and Criuleni [10]; *quarries for extraction of sand* from Florești, Telenești and Orhei districts; *glass factory* from Florești town; *the gypsum production factories* from Bălți and from Biruința of Sângerei district; *companies for producing of concrete products* from towns of Bălți, Orhei, Florești and Râşcani; *companies for producing of peat and gravel* from districts of Râşcani, Florești, Orhei (Orhei town, Brănești, Pohorniceni, Piatra, Vîşcăuți villages) and Criuleni (Maşcăuți village); *production centers for pressed bricks and of pavement hobs* from Bălți municipality and district centers. In the Bălți municipality, a large water consumer is the thermal power plant CET-Nord SA (204,000 m³). Also, a significant volume of water for technological purposes is used by public enterprises for providing water supply and sanitation services in the town of Bălți (855,000 m³), Florești (65,000 m³), Orhei (35,000 m³) Telenești, Sângerei, as well as by the markets points and car wash from Bălți town and from districts centers [3]. Also, average water consumption is attested at the woodworking enterprises for Bălți, Drochia, Telenești and Orhei towns, the transport enterprises, especially railway transport companies and bus parks in Bălți, the fuel trading stations [28].

The total volume of water used in the industry decreased, during the analyzed period, by ≈ 2 times (Figure 5), which is due mainly to reducing the volume of water use at the industrial enterprises from Bălți. Also, the reduction of the volume of water used for technological purposes is not only due to the reduction of the production volume and the bankruptcy of many industrial enterprises, but also to the technological modernization of many industrial enterprises, especially wine factories and meat and milk processing centers [26]. The largest reductions of water volume used for industrial purposes are recorded in the districts of Florești (≈ 5 times), Călărași and Râșcani (≈ 4 times), Rezina (2.3 times). At the same time, the increase of volume of water used in industry is registered in the districts of Drochia (2.3 times), Fălești (2.2 times), Telenești and Orhei (+3%), being conditioned by relaunching of the food companies from these districts and by increase of water use in the industrial sector.

Water supply of localities into Răut river basin is assured, to a great extent, also with non-centralized water sources. According to data of Ecological Inspectorate, in the Răut river basin 55,500 wells were identified, most of which are located in the upper (northern) course of this hydrographical basin, including 13.7 thousand wells in the Drochia district, 6.6 thousand wells in Dondușeni district and 4.8 thousand in the Soroca district (Table 3). The large number of wells in these districts demonstrates the

significant role of non-centralized water sources and high share of unaccounted water consumption. A much smaller number of wells are in the middle and lower courses of this basin, where most wells are located in the districts of Sângerei (5.2 thousand), Orhei (4.3 thousand), Florești (4.0 thousand) and Telenești (3.6 thousand), Rezina (2.2 thousand) and Şoldănești (2.1 thousand). Overall, 89% of the wells are arranged and can be used as a source of drink water for supply the population, for plants and animals breeding near the house. At the level of localities, the number of wells depends both on the size of villages and towns, such as on the available volume and storage characteristics of groundwater reserves. Thus, the maximum number of wells is found in the Drochia town (1,692) and in the village of Pelenia (1,318) and Sofia (1,287) from the Drochia district. About 700 wells are in the villages Pirlița and Răuțel from Fălești district, Sturzovca from Glodeni district.

Also, 886 springs are used for water supplies, out of which 2/3 are arranged. At the level of localities and districts, the number of springs depends on their surface and hydrological peculiarities [10]. In addition, the official data on this subject are also influenced by the activity of recording and monitoring of water resources, including springs and wellsby ecological and sanitary authorities. Most of the springs are located in the districts of Soroca (209), Drochia (154) and Orhei (129). In the Drochia district is the critical situation, because only 32% of the springs are arranged.

| | Districts | W | ells | Springs | | | |
|----|--------------------|--------|----------|---------|----------|--|--|
| | Districts | Total | Arranged | Total | Arranged | | |
| 1 | Ocnița | 1,175 | 1,162 | 12 | 11 | | |
| 2 | Dondușeni | 6,633 | 6,105 | 63 | 53 | | |
| 3 | Soroca | 4,847 | 4,089 | 209 | 122 | | |
| 4 | Florești | 4,036 | 3,642 | 89 | 82 | | |
| 5 | Drochia | 13,679 | 12,412 | 154 | 49 | | |
| 6 | Edineț | 486 | 486 | 2 | 2 | | |
| 7 | Fălești | 2,486 | 2,441 | 6 | 3 | | |
| 8 | Glodeni | 881 | 835 | 19 | 15 | | |
| 9 | Râșcani | 3,152 | 3,087 | 58 | 28 | | |
| 10 | Bălți municipality | 1,643 | 1,523 | 18 | 18 | | |
| 11 | Sângerei | 5,175 | 3,726 | 5 | 5 | | |
| 12 | Şoldănești | 2,064 | 1,994 | 27 | 23 | | |
| 13 | Rezina | 2,188 | 1,630 | 66 | 36 | | |
| 14 | Telenești | 3,575 | 3,104 | 23 | 23 | | |
| 15 | Ungheni | 162 | 155 | 2 | 1 | | |
| 16 | Călărași | 120 | 85 | 2 | 2 | | |
| 17 | Orhei | 4,326 | 3,791 | 129 | 109 | | |
| 18 | Criuleni | 27 | 23 | 2 | 1 | | |
| 19 | Dubăsari | 87 | 79 | 1 | 1 | | |
| | Total | 56,703 | 50,408 | 886 | 585 | | |

Table 3. The number and status of wells and springs in the Răut river basin (2017).

Source: State Ecological Inspectorate [11]

In the Răut river basin, lakes also represent an important source of water. In the study region there are monitored 1,419 lakes with a total area of 828 ha (Table 4). Most of these aquatic basins were built in the 70s-80s of the last century, mainly for of river flow conytrol and for fishery. The largest ones were managed by big fisheries, which were later turned into self-management or privatized. The number of lakes and their area are determined by the share of localities in this basin and by the length of the watercourses frequented by these basins, as well as by the presence of the fishery farms [10]. Most of the lakes are located in upper and middle course of Răut river basin, especially in the districts of Dondușeni (226), Drochia (220), Râșcani (185) and Sângerei (173). At the local level, most of the lakes are arranged in the Nihoreni (45) and Vasileuți (26) villages from the Râșcani district. In the lower course of the Răut river basin we have fewer lakes, but we can mention the communes of Ivancea (10, all being used for fish farming) and Puţuntei (9, for irrigation) from Orhei district; Suhuluceni (8), Crăsnășeni (7) from Telenești district; Meleșeni (9) and Săseni (8) villages from Călărași district. Approximately 60% of the lakes in the Răut river basin are arranged on water courses, which have a massive negative impact on the leakage and available water resources, especially in the lower course of the Răut River [3,10]. The maximum number

of lakes on river course is attested in the districts of Drochia (158), Sângerei (155) and Orhei (105), which are crossed by Răut River (Table 4).

| Districts | | Number | | Surface | The usage categories | | | | |
|--------------------|-------|-----------|----------|---------|----------------------|---------|------------|------------|--|
| Districts | Total | on course | laterals | ha | General | Fishery | Irrigation | Recreation | |
| Ocnița | 18 | 4 | 14 | 85 | | 16 | 2 | | |
| Dondușeni | 226 | 10 | | 770 | 75 | 151 | | | |
| Soroca | 69 | 1 | 68 | 189 | 41 | 28 | | | |
| Florești | 79 | 41 | 38 | 568 | 18 | 34 | 11 | 2 | |
| Drochia | 220 | 158 | 62 | 1,122 | 85 | 122 | 4 | 1 | |
| Edineț | 6 | | | 29 | | 3 | | 3 | |
| Fălești | 53 | 32 | 21 | 333 | 19 | 34 | | | |
| Glodeni | 48 | | 48 | 161 | 5 | 43 | | | |
| Rîșcani | 185 | 38 | 148 | 862 | 119 | 66 | | | |
| Bălți municipality | 21 | 20 | 1 | 141 | 4 | 17 | | | |
| Sângerei | 173 | 155 | 18 | 1,418 | 77 | 93 | 3 | | |
| Şoldănești | 9 | 8 | 1 | 34 | | 8 | | 1 | |
| Rezina | 12 | 5 | 2 | 131 | 6 | 3 | 2 | 1 | |
| Telenești | 99 | 8 | 91 | 1,358 | 80 | 7 | 12 | | |
| Ungheni | 19 | 19 | | 199 | 6 | 13 | | | |
| Călărași | 51 | | 51 | 176 | | 15 | | 36 | |
| Orhei | 124 | 105 | 19 | 815 | 71 | 36 | 16 | 1 | |
| Criuleni | 6 | 6 | | 36 | 1 | 4 | | 1 | |
| Dubăsari | 1 | | 1 | 0.4 | 1 | | | | |
| Total | 1,419 | 826 | 583 | 8,428 | 601 | 695 | 50 | 48 | |

Table 4. The status and usage of the lakes in the Răut river basin (2017).

Source: State Ecological Inspectorate [10]

The maximum surface of lakes and reservoirs is attested, also, in the districts of Sângerei (1,418 ha), Telenești (1,358 ha), Drochia (1,122 ha), Râșcani (862 ha) and Orhei (815 ha). The biggest lakes are in the middle and lower courses of Răut hydrographical basin, including in the Iezareni Vechi (124 ha) and Chișcăreni (116 ha) villages from Sângerei district, Verejeni (212 ha), Ghiliceni (97 ha) and Mândrești (57 ha) villages from Telenești district, Brăviceni village (74 ha) from Orhei district.

Approximately 50% of the lakes are used for fishery purposes, 43% are of general use, 3% for irrigationand for recreation. Most lakes used for fish farming are in the districts of Donduşeni (151) and Drochia (122), at Sturzovca village from Glodeni district, with 29 basins used for this purpose. In the Râşcani and Teleneşti districts, more than 60% of the basins are of general use. Most of the lakes used for recreation are concentrated in the lower course of the Răut river basin, especially in the Orhei (Ivancea village) and Călăraşi districts. This is due to the higher access to these aquatic objectives and to proximity to the Chişinău municipality.

5. CONCLUSIONS

About 60% of the waters used in Răut river basin are from underground sources that predominate in the absolute majority of districts and localities from this hydrographical basin. The predominant use of underground water is conditioned by the low flow of water courses and lakes, to the intensification of climate changes, and to reduced capacity to exploit the water surface sources.

On average, during the analyzed period, the volumes of water used for domestic and agricultural purposes are almost identical, both having a share of 43% of the total volume, but the water used in agriculture decreased by ¼ and for domestic purposes increased about 50%. The significant increase in the volume of water used for domestic purposes is due to the rapid expansion of public water supply systems, especially in rural areas, based on underground sources of water.

12% of the total volume of used water goes for irrigation and only 14% is used for industry. A very significant decrease of water used for this purposes has been registered in the analyzed period, which is conditioned by bankruptcy and technological modernization of many farms and industrial enterprises.

In the Răut river basin were identified 55,5 thousand wells, most of which are located in the upper (northern) course of this hydrographical basin. Approximately 90% of the wells are arranged and can be used as a source of drink water for population.

The absolute majorities of general purpose lakes is public property and are managed by the mayoralties, while the fisheries are managed by private operators, including from outside the Răut river basin. Most of the lakes are located in upper and middle course of Răut river basin, but the lakes for recreation purposes are arranged, predominantly, in the lower course, in theproximity to the Chişinău municipality. Approximately 60% of the lakes in the Răut river basin are arranged on water courses, which have a massive negative impact on the leakage and available water resources, especially in the lower course of the Răut River.

For future research, we propose to analyze the relationship between the dynamics of public water supply systems and the water consumption per capita, as well as the influence of these indices on the health status of the population in the Raut river basin.

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